THE GERMINATION OF HYDRASTIS CANADENSIS.

BY HENRI HUS.

Hydrastis canadensis L., popularly known as Golden Seal, Orange-root, Yellow Puccoon and by numerous other names, is one of our native plants of more than ordinary interest. Not only is it frequently planted in eastern gardens on account of its decorative effect and especially because of its crimson fruit, but as a plant of reputed therapeutic value it is often grown on a comparatively large scale for pharmaceutical purposes. This cultivation is becoming more important as the years go by. A vast army of collectors is scattered throughout the United States, gathering the plant in its wild state. A time will undoubtedly come when the supply from this source will fall far short of the demand, and when it will become necessary to take recourse to artificial sources to furnish the trade with the requisite amount.

The commercial article consists of the dried rhizomes, which are official in the Pharmacopoeia of the United States and in many other countries. Especially in Europe the greater value of Hydrastis in gynecological practice as compared with the various, frequently unreliable, preparations of Ergot, is becoming more and more recognized. The active principle contained in the rhizome is an alkaloid, hydrastine, which, according to Lloyd,* occurs to a lesser extent in the roots. Unfortunately for the grower, the propagation of this plant, as commonly practiced, is by means of division of the rootstock, and though a single one, four years old, may be divided into three or four pieces,† a considerable pecuniary

* Lloyd, J. U. and C. G. Drugs and Medicines of North America. **1.** Ranunculaceae. 1884–85. Here a very complete list of the earlier pharmaceutical, medical and botanical literature of *Hydrastis* may be found.

† Rhizomes, six to ten years old, may possess from 20 to 60 fertile stems. — See Homer Bowers, A contribution to the life-history of *Hydrastis canadensis*. (Bot. Gaz. **16**: 73).

Alice Henkel and G. F. Klugh, in Bulletin 51 of the Bureau of Plant Industry, U. S. D. A., mention that by a division of 40 plants, the next year 150 plants were obtained, an increase of 275%.

loss is involved in the perpetuation of the crop. Hence it has frequently been suggested that the seed should be used for purposes of propagation.

Though some have obtained excellent results from their efforts along this line, apparently the method has not commended itself to the majority, a variety of reasons having been assigned for the non-success. Two, most frequently brought forward, are the long time, *i. e.*, at least three years, which must necessarily elapse before a plant raised from seed has reached a marketable size, the other that either the seed refuses to germinate or that the young plants die shortly after germination.

Since *Hydrastis canadensis* does best in rich woods, of which large tracts may be had at a comparatively low rental, and, once planted, requires no care except an occasional hoeing,* the validity of the first objection may be questioned. As to the non-germination of the seed, this is a point open to discussion.

The seed must be obtained as early as possible. The Golden Seal ripens its fruit in July and August, the ovaries, which are present to the number of twelve or more, becoming crimson, one- or two-seeded berries. These are soon eaten by birds. The first thing to do then is to gather the fruit as soon as ripe. Leaving it in a shaded, well-ventilated place, the berries will soon dry, when the seed can be cleaned and at once sown. The importance of sowing fresh seed can not be too greatly emphasized; it is one of the essentials of success. In the case of many plants, horticulturists fully realize the necessity of sowing fresh seed only. This seems to be especially true of many members of the buttercup family. Hildebrand† points this out for the genus *Anemone*.

In sowing, the necessity of reproducing as nearly as possible natural conditions, must be remembered. This has sufficiently been shown by a number of investigations of which it is only necessary to mention those of the late B. Schmid,‡

* Bowers, H. *l. c.* p. 81.

† Hildebrand, F. Einige Beobachtungen an Keimlingen und Stecklingen. (Bot. Zeit. **50** : 1. 1892).

‡ Schmid, B. Beiträge zur Embryo-Entwickelung einiger Dicotylen. (Bot. Zeit. **60** : 207. 1902).

who studied the germination of *Eranthis hiemalis*, *Corydalis cava*, *Ranunculus Ficaria*, *Bunium Bulbocastanum* and *Cyclamen persicum*. From his experiments it becomes apparent that the medium is of but little importance as long as proper conditions of temperature and moisture obtain. The protective action of woods, preventing extremes of temperature and moisture, has been shown by Ebermayer,* who is quoted by Schmid in the paper just mentioned. Comparative observations made in Europe, in a beech-forest situated at an altitude of 400 m., gave the following results:

TABLE A.

	In the wood.		In the open.	
Temperature	max.	min.	max.	min.
At surface	21.5°		28.6°	
One-half foot below surface	18.4°	−2.5°	24.5°	−4.6°

SOIL AND SURFACE TEMPERATURES.

From this it will be seen that at the surface the highest temperature was 7.1° higher in the open than in the wood, while ½ foot below the surface a difference of 6.1° C. was found. It will also be noted that in winter the temperature of the soil ½ foot below the surface was considerably higher in the wood than in the open.

Of paramount importance to the modified temperature of the forest, is, as Schmid points out, the fairly uniform humidity of its soil. In the woods there is but little danger of desiccation as a result of prolonged summer-drought, which in the open occasionally affects even the deeper layers of soil.

In the wood, the natural habitat of *Hydrastis canadensis*, where the ground is covered first by a layer of dry and decaying leaves, and secondly by a layer of leaf-mold, the seed of this plant evinces no trouble in penetrating to a depth of several inches. To insure germination, similar conditions would probably have to be reproduced. However, it remains

* Ebermayer, E. Die physikalischen Einwirkungen des Waldes auf Luft und Boden etc. **1.** Aschaffenburg. 1873.

a question what depth is the best suited to this purpose. With this in view, an experiment was undertaken in the fall of 1906.

Having obtained fresh seed from the vicinity of St. Louis, through the kindness of Mr. O. S. Ledman of the Luyties Pharmaceutical Co., it was sown on August 15, 1906, in lots of 25 in 5-inch pots, containing a mixture of equal parts loam, sand and leaf-mold, which filled the pots to within one inch from the top. The seed was then covered by ½ inch of the same mixture. Eight pots, thus prepared, were arranged in a box in such a manner that the surface of the soil in the first pot was exactly ½ inch, and that of the soil in the eighth pot was exactly 7½ in. below the top of the box, and the seeds

TABLE B.

Depth in inches below surface.	Number germinated.		Not germ. but in good cond.		Total germ. or in good cond.		Number decayed.	Number not acc. for.	Total number dec. or not acc, for.	
	No.	%	No	%	No.	%			No.	%
1	2	8	0	0	2	8	6	17	23	92
2	10	40	1	4	11	44	12	2	14	56
3	12	48	0	0	12	48	8	5	13	52
4	6	24	3	12	9	36	16	0	16	64
5	14	56	0	0	14	56	7	4	11	44
6	8	32	1	4	9	36	10	6	16	64
7	14	56	0	0	14	56	11	0	11	44
8	8	32	0	0	8	32	13	4	17	68

RESULTS OBTAINED BY SOWING SEEDS OF HYDRASTIS IN LOTS OF 25 EACH AT DEPTHS VARYING FROM ONE TO EIGHT INCHES.

respectively 1 and 8 inches below the top. The other pots were so placed between these two that each stood exactly one inch lower than did its predecessor. The remaining space was then filled with a mixture of leaves and old horse-manure containing much straw. The box was placed in a well-drained cold frame. After the cold weather set in, the frame was covered during the night with a sash, which was always removed during the daytime, except when extreme cold prevailed, or during heavy snow or rainstorms. Thus it was hoped to reproduce natural conditions as advantageously as possible. The box was watered slightly from time to time, as was deemed advisable.

On February 12, 1907, the pots were removed from the box and the seeds were counted, the fact whether they had germinated or remained unchanged, externally at least, or had decayed, being noted. The results obtained are shown in the accompanying table (B) and diagram (I). In the latter, the ordinate gives the number of seeds and the abscissa the number of inches below the surface of the soil at which the seed lay. The number of seeds germinated is shown by a full line; the number germinated or in good condition at the end of the experiment, by a dotted line; and the total number decayed or unaccounted for, by a broken line.

It will be noted that of the seeds placed 1 inch below the surface but 2 germinated and but 6 decayed seeds were found, 17 remaining unaccounted for. It may be assumed that in the case of the latter, decay had progressed so far as to make them unrecognizable.

In the case of the second pot, in which the seed had remained 2 inches below the surface of the mulch, 10 seeds had germinated, one was found not to have germinated but to be still in good condition, while 12 were found to be decayed and 2 were unaccounted for.

Where the seed had been buried 3 inches below the surface, 12 seeds were found to have germinated, 8 were decayed and 5 unaccounted for.

In the next pot but 6 seeds had germinated, 3 were found to have remained apparently unchanged, while 16 were found to have decayed.

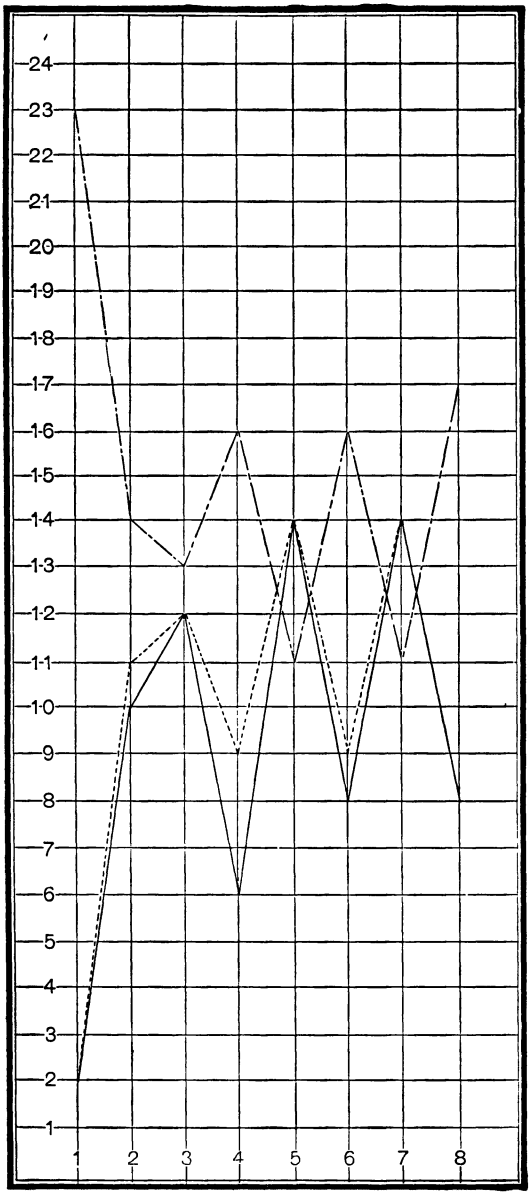
The pot in which the seed had been placed 5 inches below the surface, showed that 14 had germinated. Seven decaying seeds were found, no trace of the other four remaining.

In the sixth pot 8 seeds were found to have germinated, 1 having remained unchanged, 10 being decayed and 6 unaccounted for.

The conditions met with in the fifth pot were again encountered in the seventh pot, with the exception that all decayed seeds could be counted.

The last pot yielded 8 germinating seeds and 13 decayed ones, 4 being unaccounted for.

DIAGRAM I.



RELATIVE NUMBER OF SEEDS OF HYDRASTIS WHICH GERMINATED OR DECAYED AT VARIOUS DEPTHS.

The experiment was conducted on too small a scale to attach any great importance to the fluctuation in the percentage of germination obtained at various depths. The low germination percentage at 6 inches below the surface appears inexplicable. It is different with the low percentage of germination obtained in the case of the fourth pot, which occupied the frost line, as was determined by repeated observations. The results obtained with the second and third pots, respectively 40% and 48% germinated, and 44% and 48% either germinated or in good condition, compared with the results yielded by the fourth pot, 24% germinated and 36% germinated or in good condition, might lead one to believe that a position of the seed where it is exposed to a protracted low temperature, but not subject to repeated thawing, is less detrimental than a position where it can be reached only by a rather severe frost, coming in the middle of the winter but where the seed has already received the benefit of the higher temperature of the deeper soil-layers.

Not taking into account the results obtained with the first pot, the average percentage of germination obtained is over 40%. From this it may be concluded that there is no valid reason why Golden Seal should not be raised from seed, provided fresh seed is used, which, when in the soil, is protected from extremes of temperature. For practical purposes it would be best to sow the seed in a well-drained frame, in the soil, not in pots. The soil should be a mixture of loam, leaf-mold and sand, and be at least one foot deep. The seed is to be covered with at least ½ inch of the same mixture and the whole mulched to a depth of 6 inches. Sufficient protection to keep the frost from the seed must be given during the coldest winter weather. In the early spring the mulch is to be removed.

The development of *Hydrastis canadensis* was fully described some years ago by a practical grower, Mr. Homer Bowers.* In this paper is given a detailed description of the condition of the plants during the first year of their existence, a condition which is similar to that met with in

* Bowers, H. *l. c.* p. 74.

*Eranthis hiemalis** and others. The similarity between the first-year stage of this plant and that of the May-apple, *Podophyllum peltatum*, is pointed out by Holm.†

Both have the peculiarity that during the first year of their development the plants rely entirely upon the cotyledons for that portion of their food which they must obtain from the air. These cotyledons are in evidence only during a few months and disappear during the summer. Here must be sought one of the reasons for the apparent non-success of the propagation by seed of the plant under discussion. Too readiiy the conclusion will be arrived at that the plants have died.

When, in the frame, some time after the mulch has been removed, the cotyledons make their appearance, it becomes necessary to provide shelter from the sun's rays and the drying effect of the wind. Screening is essential. Watering is necessary only when the soil threatens to become too dry. The screening must be continued during the summer, even after the seed-leaves have disappeared, and the soil must never be allowed to become dry. At the approach of winter a light mulch of leaves must be put on, and during the coldest weather some protection is to be given. The next spring, as soon as danger of extreme cold weather is over, the mulch can be removed, and each plant will produce a single leaf. The plants can remain in the frames during the summer, with the necessary sheltering and watering, and an occasional application of manure water early in the year. About August the plants can be removed to their permanent location and the frames prepared to receive the next lot of seed. Using a double set of frames, the growing of *Hydrastis* from seed will be a matter requiring but little space and less work, which after the first three years may be considered to yield a return equal to that part of the crop formerly retained for propagating purposes minus the rental of the extra land needed.

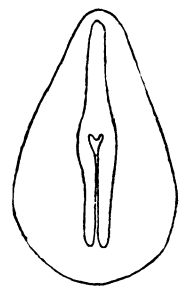
Though the number of papers dealing with *Hydrastis canadensis* is limited, from a morphological, anatomical and taxonomic standpoint the plant has received a very thorough

* Irmisch, Thilo. Ueber einige Ranunculaceen. 3. (Bot. Zeit. **18**: 221).

† Holm, Theo. *Podophyllum peltatum.* (Bot. Gaz. **27**: 419).

treatment. Especially worthy of note are, besides the articles referred to above, those of Asa Gray,* Prantl,† and the excellently illustrated and thorough treatment of Pohl.‡ At the same time, but little appears to have been published on the details of the germination, the various authors contenting themselves with descriptions and drawings of the mature seedling. For this reason use was made of the ample material at hand to furnish the plate accompanying this article.

The 12-20 spirally arranged and fleshy carpels of the single terminal flower of the Golden Seal are crimson when ripe and contain either one or two seeds. The latter are ovoid, with an average length of 3 mm., are provided with a black, hard and shiny coat and contain a fleshy albumen and a minute embryo (figure), the whole arising from an anatropous, pendulous ovule with ventral raphe.



SECTION OF SEED ABOUT TO GERMINATE.

Under natural conditions the seedlings appear in the last week of April or in the early part of May. They consist of a primary root provided with 5-6 lateral rootlets and 2 pale-green cotyledons on a short hypocotyl. The latter are petiolate, finely hirsute on both surfaces and possess one median and two lateral nerves originating at the base. Their shape is ovoid with a notched and sometimes mucronate tip. The average length is 15 mm. with a width of 10 mm. The petioles are from 25-30 mm. long and are slightly channelled, being hirsute like the cotyledons. The hypocotyl is about 5 mm. in length.

* Gray, A. Genera of the Plants of the United States. Boston. 1848.

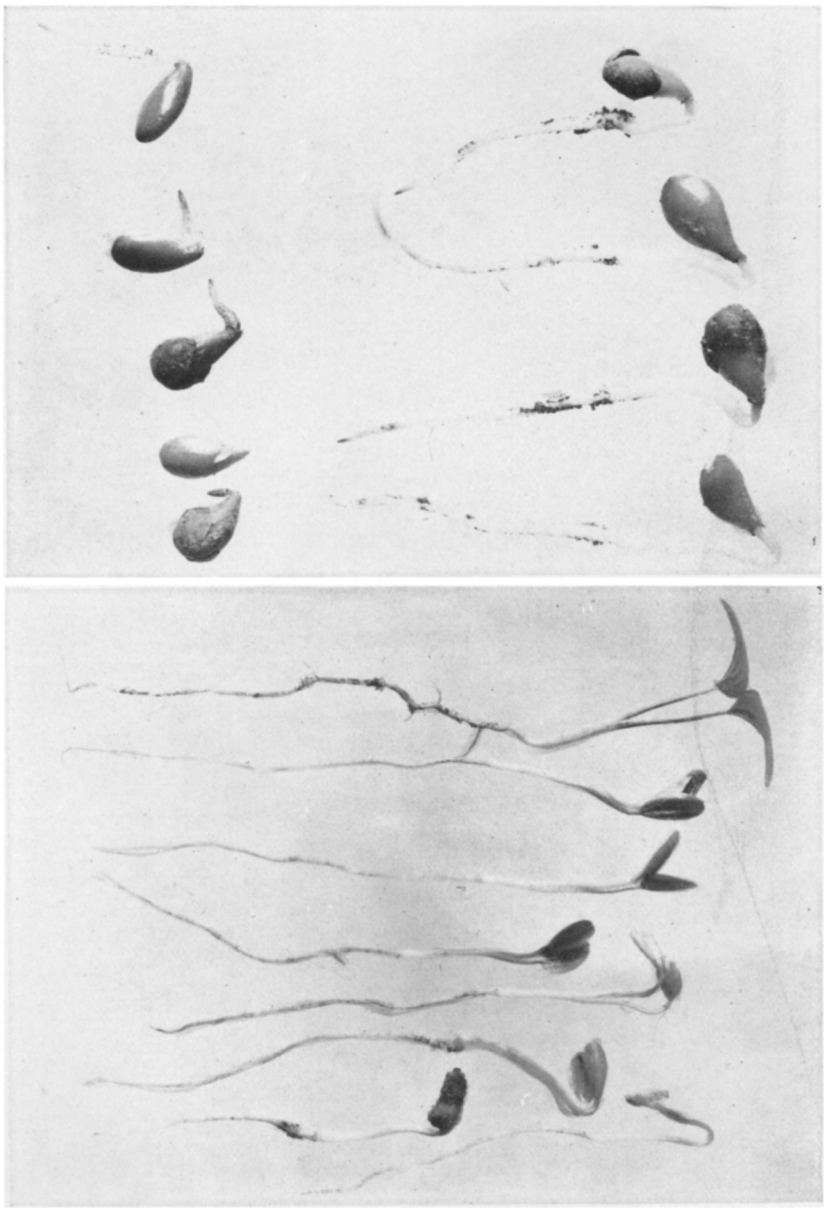
† Prantl. Beiträge zur Morphologie und Systematik der Ranunculaceen. (Bot. Jahrb. **9**: 225. 1888).

‡ Pohl, Julius. Botanische Mitteilung über *Hydrastis canadensis*. (Bibl. Bot. **6**[29]. 1894).

When the seedling becomes older the plumule may be recognized between the two cotyledons. This ordinarily does not develop until the second year. For this and later stages the reader is referred to the papers quoted above, especially to that of Julius Pohl.

EXPLANATION OF PLATE.

Plate 8.—*Hydrastis canadensis.* Germination stages, × 2; and more advanced seedlings, natural size.



GERMINATION OF HYDRASTIS.